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GB 1263323
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(54) Mixing valve

(57) A fluid mixing valve, particularly for hot and cold water, comprises a body 10 having inlets for hot and cold water 11, 12 respectively, and a proportioning valve 25 for controlling the flow of hot and cold water from the inlets to a mixing and blending duct 41 leading to an outlet 43. The proportioning valve 25 is operably coupled by a push-rod 22 to a motor 14 which is enclosed in a housing 13 mounted on the body 10, and the motor 14 is controlled through an electronic controller. A temperature probe 44 is located in the mixing and blending duct 41 to sense the temperature of the mixed water and to provide a signal to the electronic controller, which by comparison with the preset temperature required, actuates the motor to vary the proportioning valve to control the mixture of hot and cold water from the inlets.

FIG. 2

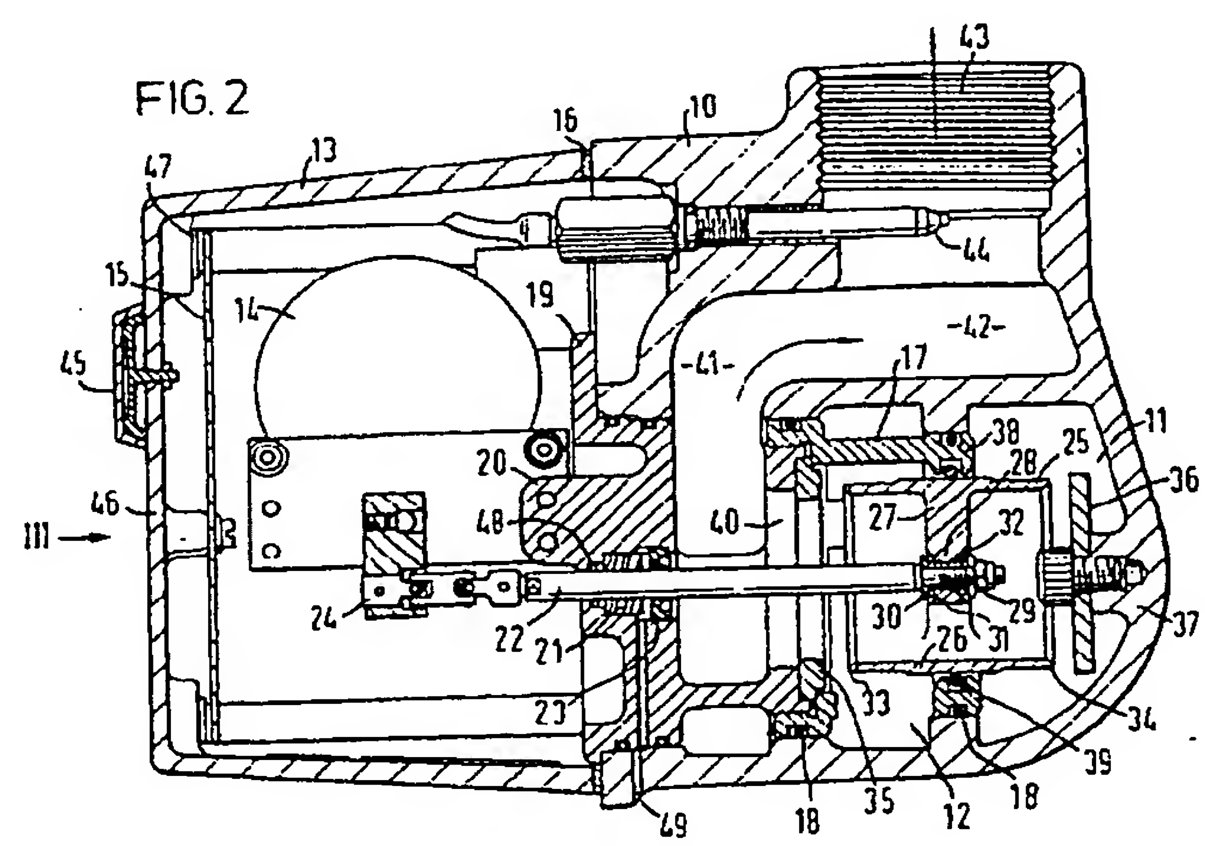

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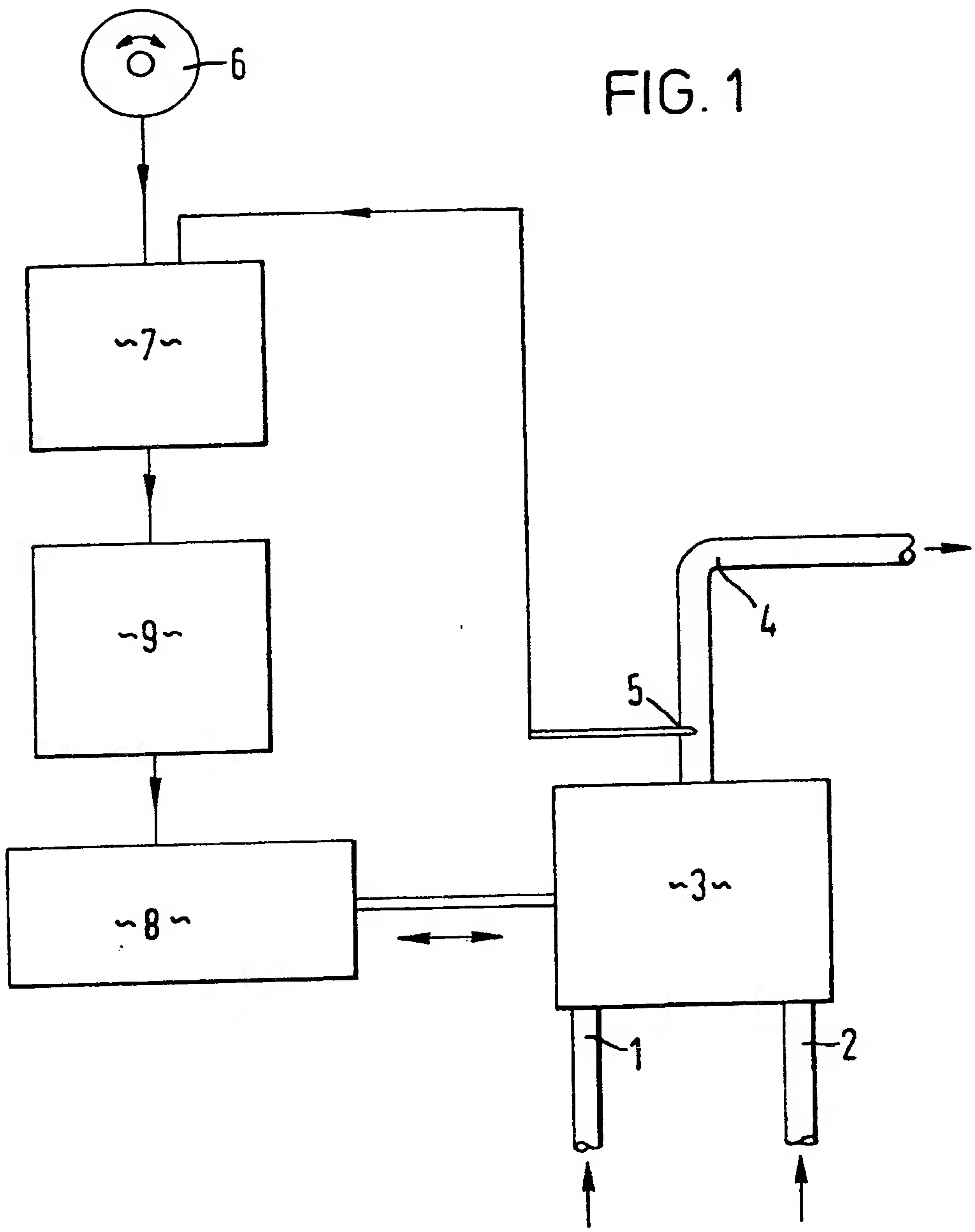
FIG. 1



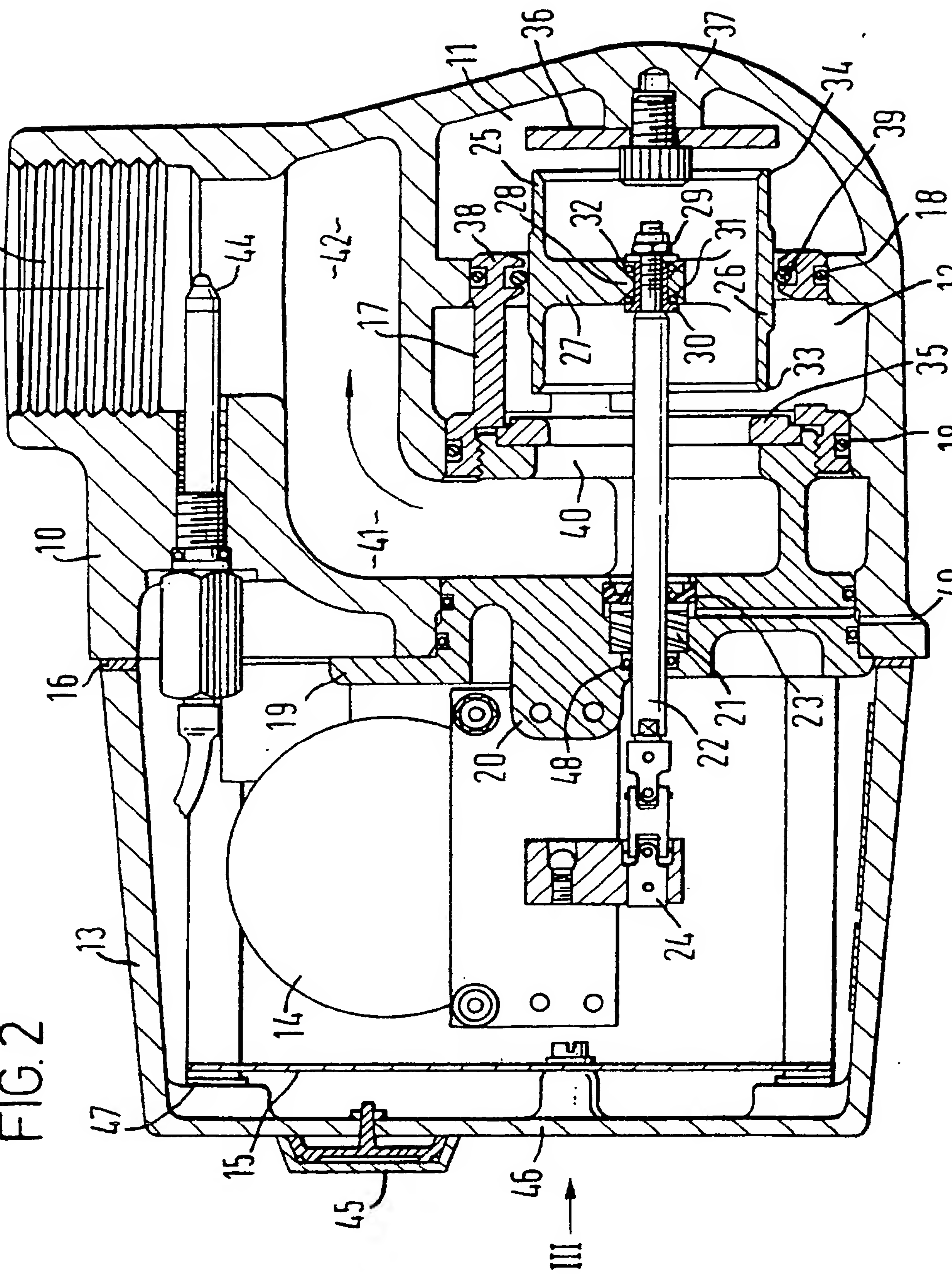

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FIG. 2

FIG. 3

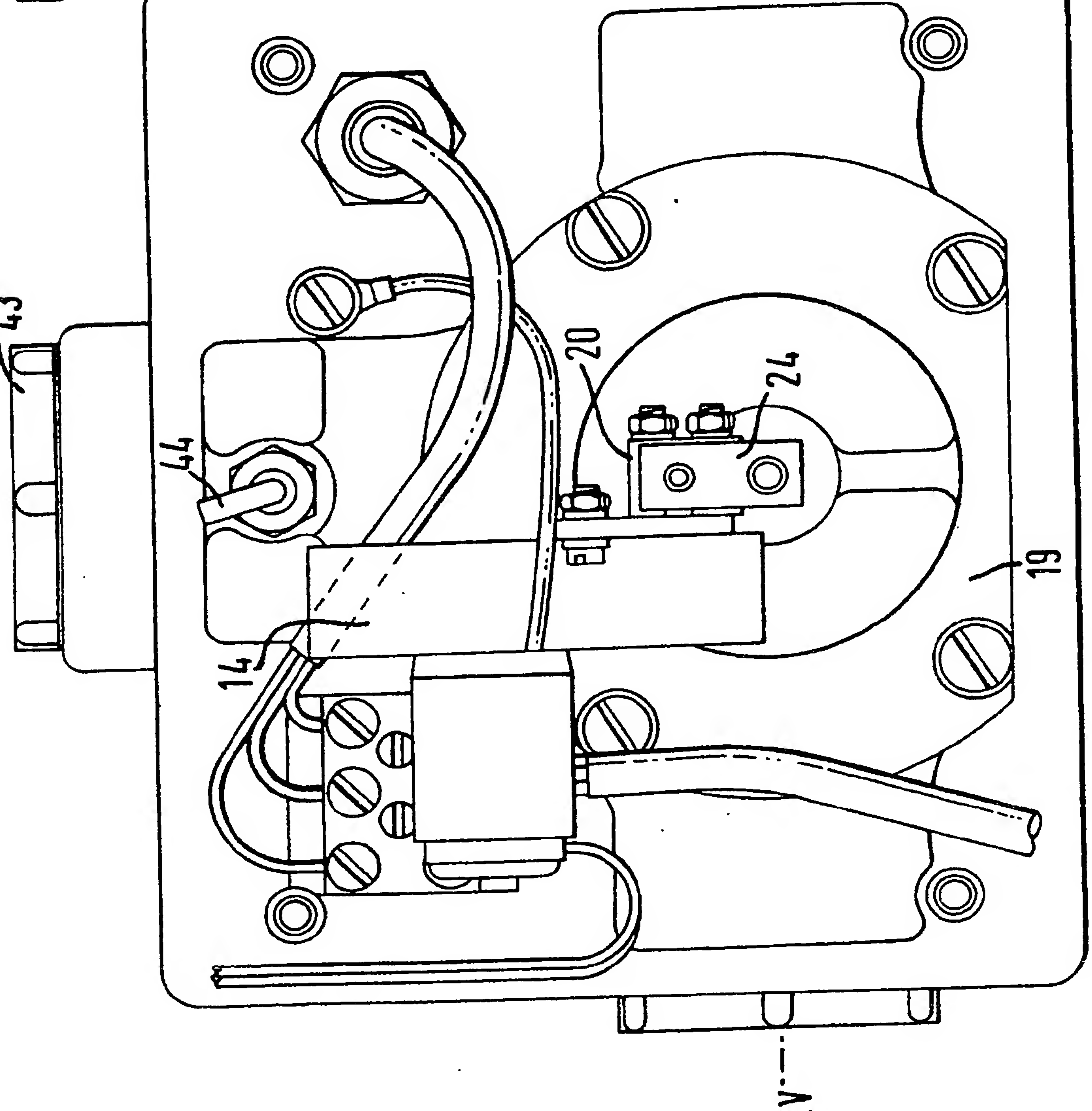
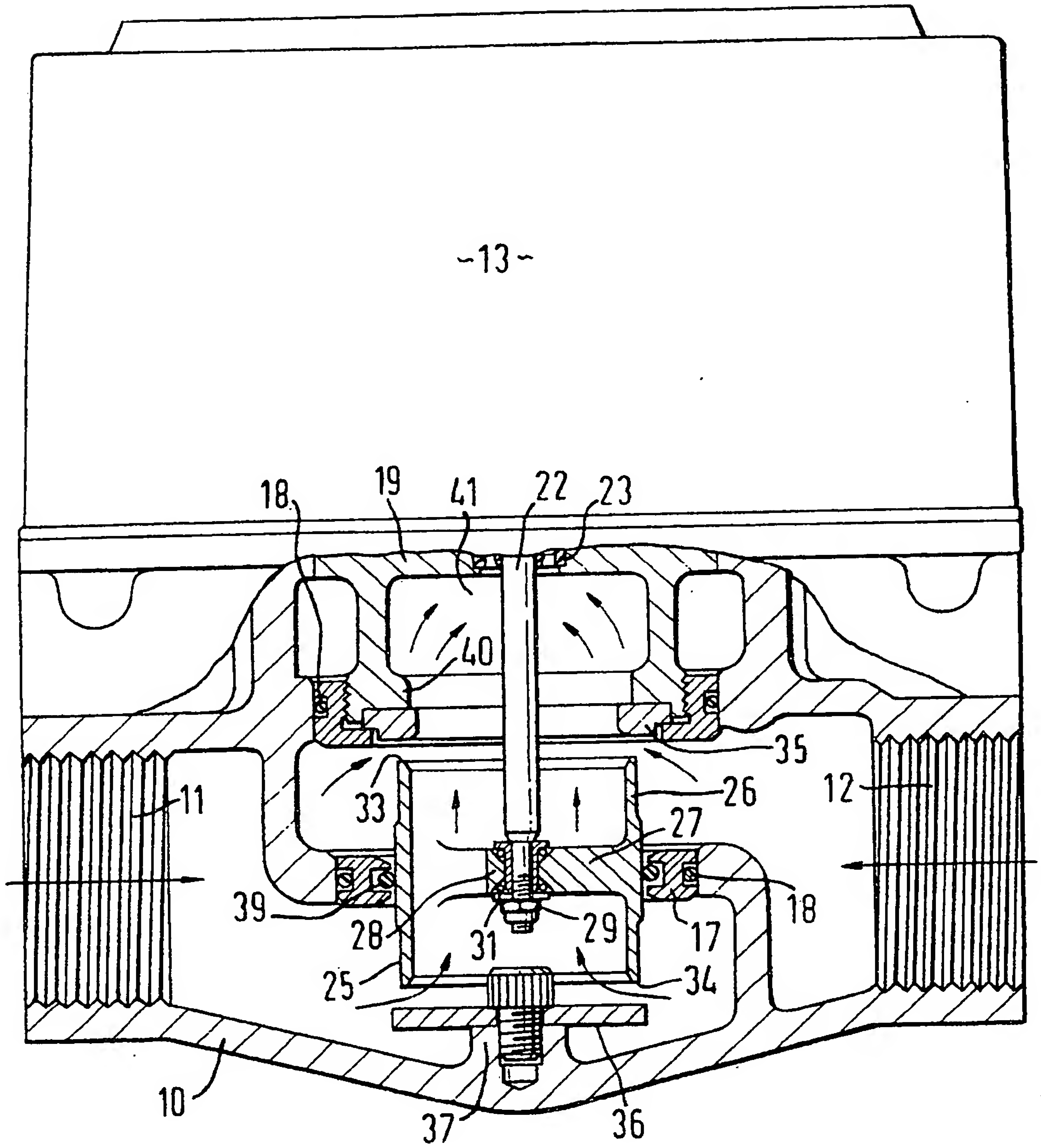


FIG. 4



SPECIFICATION

Improvements in or relating to fluid mixing devices

This invention concerns improvements in or relating to fluid mixing devices, in particular for controlling the mixing of hot and cold water together, and for controlling the blend to a selected temperature range.

It is already known to provide fluid mixing devices including valve means which serve to change or vary the proportions of hot and cold water relative to a change of temperature of the mixed water. Usually such a device has valve means which is responsive to a thermostat which is mechanically coupled or arranged to actuate the valve means. The thermostat conventionally used comprises a body which is located in a mixing chamber or fluid pathway of the mixed water downstream of the proportioning valve means and the thermostat reacts to changes in temperature of the mixed water.

This known arrangement has several disadvantages for certain applications or installations. In particular, the response time of the thermostat to temperature changes is often slow and cannot accommodate rapid variations in temperature in the mixing chamber. In many known fluid mixing devices this disadvantage is excited because thorough blending and mixing of the hot and cold water has not occurred at the location of the thermostat. Furthermore, the known type of thermostat with mechanical actuation of the valve usually relies on heat transfer from a surface in contact with the water to a thermally responsive material, such as wax, and the rate of heat transfer is slow and/or non-uniform. Additionally, with certain thermally responsive materials, the optimum performance of the thermostat is restricted to a narrow temperature range. Accordingly, where there are wide fluctuations in the temperatures of the hot and/or cold water supplies to the mixing device, for example in circulatory installations or where high rates of supply demand arise, the thermostat with mechanical actuation of the valve does not function properly. Admittedly, the installation can be modified in some cases by use of special valves in the circuit, but this is inconvenient and most costly.

It is an object of this invention to provide a fluid mixing device which obviates the foregoing disadvantages, and which is also designed to provide several improvements and advances of particular technical merit as will be explained later herein.

According to this invention we provide a fluid mixing device comprising a body having an inlet for hot water and an inlet for cold water, proportioning valve means for controlling the flow of hot and cold water from the respective inlets to a mixing and blending duct in the body, means for setting the desired temperature of the blended water, a temperature probe mounted in said duct to sense the temperature of the blended water, a motor operably connected to said proportioning valve means to actuate the valve, and the temperature probe being connected to an electronic controller for the motor to control the actuation of said proportioning valve means in response to changes in temperature in the mixing and blending duct sensed by the temperature probe.

By this device, the response time for actuating the proportioning valve can be very short, and the provision of a special mixing and blending duct ensures that the actual temperature of the blended water is sensed by the temperature probe.

Preferably, the proportioning valve means comprises a shuttle valve operably connected to the motor through a push-rod adapted to reciprocate the shuttle valve between two opposed seatings. The shuttle valve is most conveniently formed as a hollow cylindrical member which is adapted to move relative to the seatings which are respectively associated with the inlets for hot and cold water. Preferably, the seatings are annular with the interior of the valve member being arranged to provide a fluid flow path therethrough from one of said inlets. By this arrangement, the shuttle valve and seatings can be arranged to provide balancing of fluid pressures to a substantial advantage in providing for fast response on actuation of the shuttle valve by the push-rod.

Furthermore, the seatings and the shuttle valve may be arranged so that when the valve member closes on one seating, the flow from the associated inlet is stopped or closed. To ensure this the valve member and the seating are of a special type whereby any debris or build-up of scale on the valve member or seating(s) is avoided by a self-cleaning action on closing of the valve member on a seating.

The body conveniently is formed to provide two inlet chambers and a liner is mounted within the body. The shuttle valve is arranged for axial movement relative to the liner with sealing means carried by the liner engaging the exterior face of the shuttle valve member to separate the fluid flow paths of the hot and cold water. Preferably, the sealing means comprises a low friction seal which reduces resistance to relative movement of the valve member on actuation by the motor.

In a preferred arrangement, the motor is arranged to reciprocate the shuttle valve through the push-rod by means of a crank connected to one end of the push-rod and driven by the motor through a gear-box. The motor is preferably a reversible D.C. motor, and a clutch may be provided to prevent damage to the gear-box on a stall or overload condition arising. The shuttle valve is connected to the other end of the push-rod, and to enable the valve member to be self-centring on the seatings, the connection may include flexible means permitting slight self-alignment of the shuttle member relative to the push-rod and the seatings.

The body is also preferably formed with the mixing and blending duct that provides a special path for the water flowing from the shuttle valve towards the temperature probe. Preferably, the duct is of convoluted shape which induces mixing and blending of the fluid flowing therethrough, with the temperature probe being mounted in the body and projecting into the duct downstream of the convoluted extent of the duct. Accordingly, the mixing and blending duct is specially designed to ensure that at

the position where the temperature is sensed, then adequate and proper blending of the hot and cold water has occurred to avoid erroneous readings being transmitted to the electronic controller from the temperature probe.

In the preferred arrangement for controlling the proportioning of the hot and cold water by the valve means, the temperature probe comprises a thermistor of which the signal is applied to a voltage comparator of the electronic controller.

The temperature probe is desirably an assembly which can be fitted to the device easily for installation and servicing. Accordingly, as most thermistors vary, one from another, and the resistance variation is not linear in response to changes in temperature, it is also preferred to provide a control circuit in association with the thermistor which forms part of a calibrated probe assembly which has a linear response over the temperature range 20 degrees Celsius to 70 degrees Celsius. The control circuit includes resistors and other components which are arranged to provide a signal which is both linear and calibrated in respect of temperature changes and actual temperature. This control circuit is preferably a printed circuit board which is associated with a particular temperature probe thermistor so that on replacement or fitting of a temperature probe the associated circuit is also fitted easily. By such an arrangement, any calibrated temperature probe assembly can be fitted to the device and the actual temperature of the blended water to be so controlled as pre-set will be accurately maintained despite change of the temperature probe.

It is desirable for the voltage comparator to provide a signal, which, if desired, is amplified to drive or control the motor. This arrangement enables a very short response time to be achieved between the sensing of a temperature change in the blended water and the actuation of the proportioning valve by the motor. It additionally enables a very accurate control of the temperature of the blend to be achieved through a wide range of temperature differences that might arise in service.

Additionally, the electronic controller may provide a visual display of the actual temperature sensed by the temperature probe. It is also considered that a manual control, either secreted or exposed can be provided for setting the desired temperature for the blend. Conveniently, this may be achieved by having a potentiometer which is variable and of which the setting is applied to the comparator of the electronic controller.

The electronic controller is also arranged to include a stabilizing circuit which, in response to signals from the temperature probe, controls the eventual speed of the proportioning valve means to avoid the valve moving indiscriminately between opposed positions, this being called "hunting".

This stabilizing circuit is provided to avoid time lag characteristics which arise in hydraulic circuits of typical type in which the fluid mixing device of this invention would be installed.

The time lag characteristics depend on the actual circuit, but generally when a change in the temperature of the blended water is sensed, although the proportioning valve means may be actuated very quickly by the motor, in practice the flow of hot and cold water into the valve body may lag significantly. For example, the hot water supply line entering and approaching the fluid mixing device may be subject to cooling so that it takes seconds for the effective hot water to flow to and through the proportioning valve means to the mixing and blending duct where the temperature probe is located. Thus there can be a tendency for the temperature probe to provide signals during such time lag condition which can lead to instability, and the circuit for stabilizing the proportioning valve means actuation permits short period high level signals from the temperature probe to be transmitted at high gain. However, if such signal persists, the gain is reduced so that the actuation of the proportioning valve means is slowed down to compensate for the time lag in the hydraulic circuit.

Accordingly, by providing such stabilizing circuit in the electronic controller, high gain amplifiers can be used to ensure that the proportioning valve means is sensitive to small changes that are required quickly, whilst speed of response is slowed down when required to allow for time lags which occur in the hydraulic circuit.

The fluid mixing device also preferably comprises a housing which is connected to the body and which encloses the motor and the electronic controller. This provides for a compact device. To avoid heat transfer from the body to the housing, the housing is connected to the body through means arranged to provide insulation therefrom, and the body and the housing may be made of different materials if desired.

Other features of this invention will become apparent from the description of an exemplary embodiment depicted in the accompany drawings wherein:-

Figure 1 is a block diagram illustrating the principle of operation of the fluid mixing device;

Figure 2 is a sectional view of the fluid mixing device depicting the body, housing and proportioning valve means;

Figure 3 is an end view of Figure 2 taken in the direction of arrow III of Figure 2 but with the end cover of the housing removed; and

Figure 4 is a part-sectional view in the plane IV-IV of Figure 3.

With reference to Figure 1, the diagram shows that hot and cold water supplies, 1,2 respectively, enter a proportioning valve means 3. A duct 4 for mixed and blended water leads from the proportioning valve means 3 and would be connected to a plumbing installation or other water supply and distributing system in known manner. In the duct 4 there is mounted a temperature sensor or probe 5 which is preferably a negative temperature coefficient resistor such as a thermistor which is wired in parallel to another resistance and other components which are selected to make the net resistance of the temperature probe vary in a linear mode relative to changes in temperature, and to calibrate the thermistor to provide an output signal for the correct or actual temperature.

The required temperature for the mixed and blended water is pre-set by an input potentiometer 6 connected to a voltage comparison circuit 7 which is preferably a printed circuit board which may include components or circuits as desired to fulfill associated functions depending on the installation or system, for instance for time control, recording or other requirements.

The comparison circuit 7 provides a signal which is then applied to a motor and gear-box 8 through a power amplifier 9. The motor drive is coupled to the proportioning valve means 3 so that on the sensing and response to a temperature change in the duct 4 relative to the pre-set requirement, the motor actuates the proportioning valve means 3 to vary the flow of hot or cold water from the inlet supplies 1,2 to maintain the desired pre-set temperature.

With reference to the other Figures, the device for achieving this will now be described in more detail.

The device comprises a body 10 providing an inlet chamber 11 for hot water and another inlet chamber 12 for cold water. Suitable screw threads or pipe connection or glands would be provided for connection to the water supply lines. Mounted on the body 10 is a housing 13 inside of which is supported the motor which is a reversible D.C. motor with a gear-box generally referenced 14. Preferably, the motor and the gear-box 14 are coupled by a clutch or the like so that the output gears of the gear-box cannot be damaged in the event of the motor stalling, failing or being subjected to an over-load condition. The various electric connections and electronic parts including a printed circuit board 15 are also enclosed within the housing 13 which provides an enclosure for same. The body 10 and the housing 13 are bolted together, and insulated from one another by a suitable gasket 16 and spacers 47 are provided between the bolts and the housing 13. The body and the housing may be of different materials, and the housing 13 may provide a heat sink for the heat generated by the electric or electronic parts enclosed therein. The positioning and connection of the housing to the body may provide a water-tight enclosure for the electrical components.

A liner 17 is mounted inside the body 10 and is sealed thereto by O-rings 18. The liner 17 is retained in position by a support element 19 which extends into the enclosure provided by the housing. The support element 19 forms an end fitting or cap for closing the body 10 relative to the housing 13, and the support element 19 comprises a bracket 20 for the motor and gear-box 14 and has a counter-bore which seats a bushing 21 through which a push-rod 22 extends into the body 10. The push-rod 22 is sealed to the support element 19 by a lip seal 23 to prevent ingress of water from the body 10 into the housing, and there is another seal 48 on the opposed side of the bushing 21. As a safety feature, a vent 49 is provided from between such two seals to atmosphere, and in known manner the support 19 is sealed to the body 10. Accordingly, should one of the two seals 23,48 fail, a visible indication of a water leak would arise on the outside of the device through the vent 49 before water penetrates into the housing 13 where the electronic parts are situate.

The push-rod 22 is coupled for reciprocating movement to the motor and gear-box 14 by a crank assembly 24 which comprises an universal coupling to transmit the rotary motion into the reciprocating movement whilst allowing for any misalignment of the assembly.

A cylindrical shuttle valve 25 is mounted in the body co-axially with the liner 17 and comprises a generally hollow cylindrical element 26 which is provided with a central internal spider or webs 27 having an apertured hub 28. The hollow interior of the valve element 26 provides a fluid flow path for hot water from chamber 11. The free end of the push-rod 22 is connected to the hub 28 by means of a threaded fastener 29 engaging on the threaded end of the push-rod, and a flanged sleeve 30 on the push-rod provides an abutment against which a resilient member such as an O-ring 31 bears. There is a clearance opening in the hub 28, and a further resilient member 32 engages the opposed face of the hub and is held by a washer and the screw fastener 29 on the threaded end of the push-rod to a predetermined load governed by the sleeve 30. Accordingly, the resilient mounting of the shuttle valve 25 on the push-rod 22 provides for a limited amount of movement for self-centring or alignment in use.

The valve element 26 has two opposed annular sealing faces 33,34 which are respectively arranged to engage two opposed seatings 35,36 mounted in the body 10. The diameter of the shuttle valve element 26 is nearly the same as the annular sealing faces so that incoming hydraulic pressures acting on the shuttle valve are substantially balanced, and this avoids any tendency for the shuttle valve to be moved by hydraulic pressure. Furthermore, the diameter of the push-rod is small so that the effect of hydraulic pressure thereon is neglible.

The seating 36 which extends in the hot water inlet chamber 11 is provided by a metal annulus which is secured to an internal boss 37 of the body. The other seating 35 associated with the cold water inlet chamber 12 is provided by a metal annulus which is located between the liner 17 and the support element 19. Preferably, the metal annuli are made of hard stainless steel, and the respective opposed sealing faces 33,34 on the valve element are narrow annular lands formed by tapering the associated marginal end portion of the valve element. This arrangement provides for high inter-face pressures to be obtained in service between the respective seatings and the sealing faces of the valve element so that any scale build-up or other debris is crushed or removed and cannot interfere with proper performance of the shuttle valve. The use of hard stainless steel is also preferred to provide resistance to wear and corrosion in the device.

The inlet chambers 11,12 of the body are separated by the internal partitions of the body, the liner 17 and the shuttle valve 25. The liner is formed with an inwardly directed flange 38 which has an annular groove accurately locating an O-ring seal 39 which seals on the external face of the valve element 26. The seal 39 is in low tension radially inwards

towards the valve element 26 to ensure that it is maintained in light pressure engagement therewith. The seal 39 permits smooth low frictional movement of the valve element 26 in use and separates the hot and cold water inlet chambers 11,12. The low frictional resistance ensures that the power requirement for reciprocating the shuttle valve is low.

It will be appreciated from the foregoing description of the shuttle valve 25 and the associated seatings 35,36 that the seating 36 associated with the hot water inlet chamber 11 and the sealing face 34 provides a port through which hot water from the hot water inlet chamber can flow when there is clearance between such sealing face and the seating. The hot water chamber 11 is of course isolated from the cold water chamber 12 when the valve sealing face 34 engages the seating 36. In the case of the cold water chamber 12, a similar arrangement is provided with respect to the seating 35 and the sealing face 33. Accordingly, the shuttle valve in co-operation with the opposed seatings provides ports through which hot and/or cold water can flow at rates determined by the position of the shuttle valve. The hot water flow from the chamber 11 is through the internal passageway provided by the shuttle valve element 26, and is towards the other opposed seating 35 through which cold water may flow from the cold water chamber 12.

The support element 19 provides an orifice 40 leading to a mixing and blending duct 41 into which the hot and/or cold water flows from the shuttle valve. The mixing and blending duct is defined partially by the body, the liner and the support member and is especially designed to ensure adequate mixing and blending of the hot and/or cold water. The duct has a transverse portion leading from the orifice 40 which tends to impart a swirling and/or turbulent mixing of the water as it flows through the duct 41 to a reverse bend portion 42 leading to an outlet 43 from the body 10 which would be connected in known manner to the plumbing installation, system or the like by appropriate fittings, glands or like connections.

The mixing and blending duct 41 is of substantially convoluted form to generate blending of the mixture and to avoid pockets of hot and/or cold water when the mixture reaches a temperature probe 44 which is mounted in the body 10 and extends into the duct downstream of the convoluted fluid path.

The temperature probe 44 is arranged to extend into the mid-stream of the flow of the blended water and, as aforementioned, comprises a thermistor which has an associated calibration and linear control ciruit that is connected to the electronic controller including the printed circuit board 15 mounted in the housing 13.

The temperature probe 44 is also connected to a visual digital display panel 45 located on the end panel 46 of the housing so that the actual temperature of the blend is immediately visible. The electronic controller also includes the variable potentiometer (not shown) which may be pre-set by a screw-driver, or by a control knob with indexing marks in known manner to indicate the temperature setting. Alternatively, the electronic circuit may be adapted to provide a visual indication of the pre-set temperature by a suitable switch or by-pass which can be activated when the variable potentiometer is adjusted or needs to be checked.

The capacity and performance of the various electronic and/or electric components are selected so that in normal use they are substantially underrated and thus give maximum life and safety factors.

Additionally, the device is arranged so that it can be plumbed to hot and cold supplies in the reverse positions, that is for the above-described hot and cold water inlet chambers to be reversed. A simple changeover plug for making the electrical connection to the motor and gear-box through the electronic controller can be provided and this reverses or inverts the proportioning direction of movement of the shuttle valve.

It has been found in service of the invented device, that accurate temperature control can be achieved of the order of plus/minus 1 degree Celsius or even less. Furthermore, it has been found that the fluid mixing device can operate through a very wide range of flow rates, for example in the range of 300 litres per minute to 10 litres per minute. These flow rates approximate for a maximum flow rate likely to be required in a pumped circulatory system to the minimum of an idle circuit.

The advantages of providing the visual display of the actual temperature and other features mentioned previously will be appreciated by those skilled in the art. Additionally, the manufacture and construction of the fluid mixing device are such as to achieve high reliability, ease of manufacture, assembly and servicing if required, and installation for service.

CLAIMS

1. A fluid mixing device comprising a body having an inlet for hot water and an inlet for cold water, proportioning valve means for controlling the flow of hot and cold water from the respective inlets to a mixing and blending duct in the body, means for setting the desired temperature of the blended water, a temperature probe mounted in said duct to sense the temperature of the blended water, a motor operably connected to said proportioning valve means to actuate the valve, and the temperature probe being connected to an electronic controller for the motor to control the actuation of said proportioning valve means in response to changes in temperature in the mixing and blending duct sensed by the temperature probe.

2. The device according to claim 1 wherein the proportioning valve means comprises a shuttle valve operably connected to the motor through a push-rod adapted to reciprocate the shuttle valve between two opposed seatings.

3. The device according to claim 2 wherein the shuttle valve is a hollow cylindrical member which is adapted to move relative to the seatings which are respectively associated with the inlets for hot and cold water.

4. The device according to claim 3 wherein the seatings are annular with the interior of the valve

member being arranged to provide a fluid flow path therethrough from one of said inlets.

5. The device according to claim 4 wherein the seatings and the shuttle valve are arranged so that when the valve member closes on one seating, the flow from the associated inlet is stopped or closed.

6. The device according to claim 5 wherein the sealing face of the shuttle valve member is formed as a narrow edge arranged to close and seat on an associated seating.

7. The device according to any one of claims 2 to 6 wherein the body is formed to provide two inlet chambers and a liner is mounted in the body with the shuttle valve being arranged for axial movement relative to the liner with sealing means carried by the liner engaging the exterior face of the shuttle valve member to separate the fluid flow paths of the hot and cold water.

8. The device according to claim 7 wherein the sealing means comprises a low friction seal.

9. The device according to any one of claims 2 to 8 wherein the motor is operably coupled to the shuttle valve through the push-rod by a crank connected to one end of the push-rod by a coupling and driven by the motor through a gear-box.

10. The device according to claim 9 wherein the motor is a reversible D.C. motor and a clutch is provided between the motor and the gear-box.

11. The device according to claim 9 or claim 10 wherein the shuttle valve is connected to the push-rod through an assembly comprising self-aligning flexible means.

12. The device according to any one of the preceding claims wherein the body is formed with a mixing and blending duct of convoluted shape.

13. The device according to claim 12 wherein the temperature probe is mounted in the body and projects into the duct downstream of the convoluted extent of the duct.

14. The device according to any one of the preceding claims wherein the temperature probe comprises a thermistor of which the signal is applied to a voltage comparator of the electronic controller.

15. The device according to claim 14 wherein the temperature probe has an associated circuit forming a calibrated probe assembly for linear response through a selected operating temperature range.

16. The device according to claim 15 wherein the control circuit is a printed circuit board.

17. The device according to any one of the preceding claims wherein the electronic controller includes means giving a visual display of the actual temperature sensed by the temperature probe.

18. The device according to any one of the preceding claims wherein the controller comprises a stabilizing circuit to control the speed of movement of the proportioning valve means by the motor.

19. The device according to any one of the preceding claims wherein a housing is mounted on the body and the housing provides an enclosure for the motor and at least part of the electronic controller.

20. The fluid mixing device substantially as hereinbefore described with reference to the accompanying drawings.

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